



Studies on Internal and External Factors of Collaborative Innovation and Their Operational Mechanism among Small and Medium Sized Enterprises (SMEs)

Minghua Han^{*a, b}, Limei Wang^c

^a Faculty of Business, Ningbo University, Ningbo, 315211, China

^b Center for Collaborative Innovation on Zhejiang's Port and Shipping Logistics Service System, Ningbo University, Ningbo 315211, China

^c Ningbo Hi-tech Park KM Consulting Co., Ltd., Ningbo, 315040, China
hanminghua@nbu.edu.cn

Firstly, this paper makes theoretical analysis on the internal and external factors of collaborative innovation and their operational mechanism among SMEs. Secondly, relative study hypotheses are made based on the above analysis. Thirdly, on the basis of analysis of questionnaire survey and statistics of sample data, an empirical test is made on how driving factors work on collaborative innovation among SMEs. The study reveals that internal factors such as collaborative innovation willingness, capability of obtaining funds and human resources as well as the external factors such as government support and diffusion and application of technological innovation have positive effect on collaborative innovation among SMEs. Factor of market competition pressure has positive but not significant correlation. Finally, measures are suggested at the end of the paper to boost development of collaborative innovation among SMEs.

1. Introduction

Collaborative innovation is an effective way to enhance the capability of independent innovation of SMEs. Chen and Yang (2012) believe that science and technology, market and culture are important driving forces for collaborative innovation; Qi and Zhang (2013) point out that innovation driving forces include knowledge, government and market; Hu and Zhou (2012) reported the sources of collaborative innovation power are summarized four aspects as demand power, benefit driving force, the government impetus and attracting power of achievements.

Based on the above research, it is believed that enterprise collaborative innovation can only be achieved by effective combination of the driving factors and their interaction, but some scholars focus on the analysis and discussion of the driving factors on the whole. Although some scholars distinguish the internal and external driving power of collaborative innovation, they regard them as the dynamic mechanism of an important part of collaborative innovation mechanism. There are still insufficient in internal and external factors of collaborative innovation and empirical analysis of them. In view of this, drawing on current research, this paper makes an analysis on driving factors from two aspects of internal and external. Further on the basis of investigation, it makes an empirical test on the influence of driving factors of SMEs collaborative innovation by statistical analysis of sample data. According to the results of empirical analysis, the study presents suggestions to enhance the effectiveness of collaborative innovation in SMEs.

2. Theoretical analysis and research hypothesis of driving factors and their mechanism of collaborative innovation in SMEs

2.1 Internal Driving Factors Analysis

(1) Collaborative innovation willingness. Collaborative innovation activities of SMEs are carried out on the basis of effective demand of collaborative innovation which was confirmed (Di, (2007)), which depends on whether enterprises have the willingness of collaborative innovation in addition to depending on the capability of the enterprise itself. Willingness of collaborative innovation reflects initiative of SMEs to carry out

collaborative innovation, stronger willingness will help SMEs to exchange and share resources, information and achievements between the innovative subjects and it is more favourable to improve innovation performance; On the contrary, if the enterprise is not so willing to carry out collaborative innovation, which will greatly hinder innovation activities. Accordingly, this paper put forward the following research hypothesis:

Hypothesis H1: Willingness of collaborative innovation has significant effect on SMEs' innovation. Stronger willingness of collaborative innovation will facilitate SMEs' collaborative innovation and vice versa.

(2) Capital gain ability. It is widely believed that capital investment is an important guarantee for the smooth progress of enterprise innovation. These funds can be obtained by endogenous financing and exogenous financing. Because of poor self-accumulation capacity, majority of SMEs can not simply rely on own financing to meet the needs of innovation. Then, exogenous financing ability of SMEs is of important significance to get funds get necessary fund for innovation. Meanwhile, endogenous financing capacity also provides a solid basis for exogenous financing, which affect the firm's exogenous financing ability and meet the needs of collaborative innovation of SMEs. Accordingly, this paper put forward the following research hypothesis:

Hypothesis H2: Capital gain ability has a significant impact on collaborative innovation of SMEs. The more capital gain ability, the more beneficial for collaborative innovation of SMEs, and vice versa.

(3) Technological capabilities of enterprises. Technological capabilities of enterprises has the dual characteristics of static and dynamic which was confirmed (Wei(1998),Qin & Lei(2008)), the former indicates as certain internal technology knowledge stock; the latter expresses as operation and application of technology knowledge stock. The more knowledge stock or technical reserve ability SMEs have, the more favourable for them to obtain, accepting and understanding the knowledge and technology generated by collaborative innovation. At the same time, successful application of technical knowledge of SMEs will promote the enterprise to integrate and create new knowledge and technology which finally leads to accumulation and update of dynamic enterprise technology knowledge. Accordingly, this paper puts forward the following research hypothesis:

Hypothesis H3: enterprise technological capability has a significant impact on collaborative innovation of SMEs. Higher technology ability will promote collaborative innovation for SMEs and vice versa.

(4) Enterprise human resources. A variety of innovative personnel are greatly needed to participate in SMEs collaborative innovation. Among them, entrepreneurs with innovative ideas and innovative consciousness are the important driver of SMEs collaborative innovation. Managers at all levels of SMEs are important participants of the enterprises to carry out collaborative innovation. Senior managers will make the corresponding decisions according to the enterprise collaborative innovation target and task requirements, while middle managers will formulate specific implementation plan accordingly and be responsible for implementation of SMEs' innovation plan. Scientific and technical personnel can not only provide intellectual support and the necessary technical reserves for SMEs' collaborative innovation, but also an important carrier in cooperative innovation activities such as knowledge and technological innovation, achievement transformation. In addition, personnel flow between universities, research institutions and enterprises will provide convenience for SMEs to exchange knowledge innovation and technology transfer. Based on the above analysis, this paper puts forward the following research hypothesis:

Hypothesis H4: Human resources have significant impact on collaborative innovation in SMEs. Richer human resources will facilitate collaborative innovation for SMEs and vice versa.

2.2 External Driving Factors Analysis

(1) The market competition pressure. For SMEs, market competition is becoming increasingly fierce. SMEs are facing more and more severe survival pressure that becomes direct force driving them to innovate for survival. The greater the pressure, the greater the power SMES get. Due to limitation in scale, capital, personnel and other resources, SMEs are weak in market competition. It is hard for them to rely solely on internal independent research and innovation to obtain sustainable competitive advantage. Therefore, it is a rational choice for SMES to reduce the innovation cost, decentralize innovation risk and improve innovation efficiency by collaborative innovation. Accordingly, this paper puts forward the following research hypothesis:

Hypothesis H5: market competition pressure has a significant impact on collaborative innovation in SMEs. More fierce market competition will quicken collaborative innovation in SMEs and vice versa.

(2) Government support force. Because of limited innovation resources and the ability to bear the risk, government guidance needs to be introduced into the collaborative innovation of SMEs. Firstly, the formulation of relevant government policies, laws, regulations, science and technology development plan help to create a good environment for SMEs collaborative innovation. Secondly, the government investment for scientific and technological innovation not only works as a good guider but also guarantees the continuity and stability of R & D innovation investment to a certain extent. Thirdly, the guidance of collaborative innovation incentive mechanism set up by government help to gather innovation resources and innovation elements for SMEs. Accordingly, this paper puts forward the following research hypothesis:

Hypothesis H6: government support force has significant impact on collaborative innovation for SMEs. Stronger government support is more conducive to the promotion of collaborative innovation for SMEs and vice versa.

(3) Driving force of technological innovation diffusion. SMEs are the party in need of innovation resources and transfer of technology diffusion due to insufficient technological innovation knowledge and technical reserves. Colleges and universities, scientific research institutions are the important source of knowledge innovation and technology innovation. It has formed a “demand and supply” relationship for knowledge and technology innovation. Scientific research institutions set up collaborative innovation community with SMEs, transfer and diffusion of the innovation of knowledge achievement and technology, which finally promotes effective allocation of technological achievements and innovation resources for SMEs. At the same time, the diffusion and transfer of technological innovation will urge new one, and it will further facilitate innovation and technological upgrading for SMEs. Accordingly, this paper puts forward the following research hypothesis:

Hypothesis H7: diffusion of technological innovation has significant impact on collaborative innovation of technology for SMEs. More diffusion of technological innovation will help to promote the cooperative innovation of SMEs and vice versa.

3. The empirical analysis

3.1 Scale design and data collection

This study aims to reveal the effects on internal and external driving factors of collaborative innovation for SMEs, therefore relevant variables are identified as follows: Independent variables to be internal driving factors and external driving factors of collaborative innovation for SMEs. Dependent variables are considered as innovation effect for SMEs. At the same time, in order to minimize the measurement error, measurement indexes are designed for each variable. A Richter 5 point rating method is designed in survey questionnaire.

This survey mainly focuses on auto and auto parts enterprises in Ningbo region of Zhejiang, where auto parts productions have been started for a long time. Auto and auto parts industry have been developing and expanding rapidly in recent years. The respondents of this survey are mainly selected from the above industry as it has a large number of SMEs dealing in line of auto and auto parts. Questionnaires were sent by both e-mail and field work. A total of 160 copies of questionnaires were sent out and 139 copies have been responded with the responding rate 86.9%. Among them, 121 copies are valid with the efficiency of 87.1%. Relative data are analyzed by SPSS20.0.

3.2 Factor analysis and Correlation Analysis

In order to improve the quality of the sample data, this paper firstly makes validity and reliability analysis for the responded questionnaires. Reliability analysis is tested through Cronbach's Alpha system, and 0.7 is considered as the critical value of KMO for factor analysis.

Reliability analysis results show that the Cronbach's Alpha was 0.923, which is more than 0.7 standard, which means it is reliable. The validity test results show that the KMO coefficients of collaborative innovation driving factors is 0.747, KMO coefficients of collaborative innovation effect for SMEs is 0.785, all of which are greater than 0.7. And significance probability of approximate chi-square statistic value χ^2 of Bartlett's sphericity test to each subscale was 0.000, which is less than 0.01, indicating that the sample is suitable for factor analysis.

Then, factor analysis for each subscale is made by using principal component analysis method, common factor extraction standard is set that eigenvalue is greater than 1, and maximum variance method is used in the meanwhile, what's more, the common factor extracting standard is set to be greater than 0.5 or equal to 0.5.

6 new factors come out of the results of factor analysis for measurement indicators of internal and external driving factors of collaborative innovation for SMEs. New factors are named based on its index meaning included: enterprise human resources factor is labelled as X1; the collaborative innovation willingness factor as X2; government support force factor as X3; driving force factor of technology innovation diffusion as X4; market competition pressure factor as X5 and funding ability factor as X6. One new factor comes from the results of factor analysis of effect scale of collaborative innovation for SMEs which is named as collaborative innovation effect factor and is labelled as Y1.

The Pearson correlation test and analysis results of each variable resulted from factor analysis shows there is no correlation between variable X1-X6, which avoids the situation that the result of analysis may result in large deviation because of the high correlation between the independent variables during regression analysis. The variables X1-X4 and X6 and Y1 are significantly correlated when P value is 0.01 and 0.05 respectively. The variable X5 and variable Y1 have a certain positive correlation, but not a significant one. Thus, the rationality of hypothesis about the effect of driving factors for collaborative innovation in SMEs has been verified.

3.3 Regression analysis

As the order of the common factors obtaining from factor analysis is hard to be determined, so this paper adopts stepwise linear regression analysis and the results are shown in Table 1.

Table 1: The Regression Coefficients and Significance Test

| Model | | Non standardized coefficient | | Standardized Coefficient | t | Sig. |
|-------|----------|------------------------------|--------------------|--------------------------|--------|-------|
| | | B | Standard Deviation | Trial version | | |
| 1 | Constant | 5.529E-018 | .079 | | .000 | 1.000 |
| | X4 | .492 | .080 | .492 | 6.167 | .000 |
| 2 | Constant | -1.166E-016 | .067 | | .000 | 1.000 |
| | X4 | .492 | .068 | .492 | 7.282 | .000 |
| | X1 | .468 | .068 | .468 | 6.922 | .000 |
| 3 | Constant | -1.186E-016 | .055 | | .000 | 1.000 |
| | X4 | .492 | .055 | .492 | 8.951 | .000 |
| | X1 | .468 | .055 | .468 | 8.509 | .000 |
| | X2 | .430 | .055 | .430 | 7.829 | .000 |
| | Constant | -1.308E-016 | .045 | | .000 | 1.000 |
| | X4 | .492 | .045 | .492 | 10.908 | .000 |
| 4 | X1 | .468 | .045 | .468 | 10.370 | .000 |
| | X2 | .430 | .045 | .430 | 9.542 | .000 |
| | X3 | .343 | .045 | .343 | 7.601 | .000 |
| | Constant | -1.393E-016 | .042 | | .000 | 1.000 |
| | X4 | .492 | .042 | .492 | 11.784 | .000 |
| 5 | X1 | .468 | .042 | .468 | 11.203 | .000 |
| | X2 | .430 | .042 | .430 | 10.308 | .000 |
| | X3 | .343 | .042 | .343 | 8.211 | .000 |
| | X6 | .189 | .042 | .189 | 4.515 | .000 |

a. The dependent variable Y1

The results of stepwise linear regression analysis in Table 1 show that all independent variables are in the order of X4, X1, X2, X3 and X6 as they enter into the model. The earlier variables entering the model, the more influences will have on the dependent variable Y1. Variable X5 is not strongly correlated with Y1 in correlation analysis and fail to enter the regression model.

According to the model fitting situation shown in Table 2, R² and adjusting R² value are gradually increasing and have finally achieved good fitness as the model progresses,

Table 2: Model Summary

| Model | R | R ² | Adjustment R ² | F | Sig. |
|-------|-------------------|----------------|---------------------------|--------|-------------------|
| 1 | .492 ^a | .242 | .236 | 38.028 | .000 ^a |
| 2 | .679 ^b | .461 | .452 | 50.469 | .000 ^b |
| 3 | .804 ^c | .646 | .637 | 71.271 | .000 ^c |
| 4 | .874 ^d | .764 | .756 | 93.833 | .000 ^d |
| 5 | .894 ^e | .799 | .791 | 91.685 | .000 ^e |

a. predictive variable:(Constant), X4

b. predictive variable:(Constant),X4, X1

c. predictive variable:(Constant),X4,X1,X2

d. predictive variable: (Constant),X4,X1,X2, X3

e. predictive variable:(Constant),X4,X1,X2,X3,X6

The final regression model comes from the results of regression analysis, shown as Eq(1).

$$Y1 = 0.492 \times X4 + 0.468 \times X1 + 0.430 \times X2 + 0.343 \times X3 + 0.189 \times X6 \quad (1)$$

Y1 represents collaborative innovation effect for SMEs; X4 represents driving force of technology innovation diffusion; X1 represents human resources in enterprises; X2 represents collaborative innovation willingness; X3 represents government support force; X6 represents funding capacity.

3.4 Hypothesis verification results

The above data analysis show that the driving factors (X1-X4, X6) and collaborative innovation effect for SMEs (Y1) have significant positive correlation at the $p=0.000 < 0.01$ level. And the effects of relationship decreases from X4 (driving force of technology innovation diffusion whose standardized regression coefficient is 0.492), to X1 (human resources in enterprises whose standardized regression coefficient is 0.468), to X2 (collaborative innovation willingness whose standard regression coefficient is 0.430), then to X3 (government

support force whose standardized regression coefficient is 0.343); and finally to X6 (funding ability whose standard regression coefficient is 0.189). Accordingly, this paper attempts to show the above research hypothesis verification results. Accordingly, this paper attempts to show the above research hypothesis verification results as follows: Hypothesis H1, H2, H4, H6 and H7 are supported; Hypothesis H2 is rejected, Hypothesis H5 is somewhat supported.

4. The research conclusions and suggestions

4.1 Conclusions

According to the results of empirical analysis above, the paper attempts to show the following conclusions.

(1) In all internal driving factors of collaborative innovation for SMEs, driving factors as willingness of collaborative innovation, ability to obtain funds and human resources in enterprise have positive effect on collaborative innovation for SMEs, which means that the more willing for SMEs to make collaborative innovation, the more capital gain ability and the more talents, more collaborative innovation activities will be launched. As the common factor of technological capabilities of enterprises can not be extracted by factor analysis, the effect relationship between driving factors and collaborative innovation for SMEs is not clear.

(2) In all external driving factors of collaborative innovation for SMEs, driving factors as government support and driving force of technology innovation diffusion have positive effect on collaborative innovation for SMEs. That is, the stronger the support of the government and the diffusion of technology innovation strength, the more helpful expansion of collaborative innovation for SMEs. Pressure factor of market competition has positive but not significant correlation with collaborative innovation for SMEs.

4.2 Countermeasures and suggestions

Based on the above conclusion, this paper puts forward some countermeasures and suggestions to promote development of collaborative innovation for SMEs.

(1) Enhance willingness of collaborative innovation for SMEs.

SMEs' willingness of collaborative innovation is essential to promote collaborative innovation. Therefore, firstly, SMEs might constantly focus on innovation according to their own abilities and help to create an environment beneficial for collaborative innovation; Secondly, in order to be more active in collaborative innovation, SMEs might choose suitable partners and establish common aim of collaborative innovation; Thirdly, SMEs might establish a reasonable and effective mechanism of distribution of interests to arouse the enthusiasm of subjects involved in collaborative innovation based on collaborative innovation stakeholders' common interests.

(2) Promoting the effective accumulation of innovation resources and factors to provide resources demanding guarantee for collaborative innovation for SMEs.

In the aspect of finance, finance service system should be further improved to optimize the financing environment for SMEs, providing the necessary financial support for collaborative innovation for SMEs by deepening cooperation between banks and enterprises, establishing a multi-level capital market system and establishing and broadening financing channels such as innovation development fund of SMEs.

In the aspect of talent, SMEs should improve the quality of talents by offering technology training, technical guidance from experts and technical personnel continuing education and so on; On the other hand, SMEs should establish long-term talent exchange and cooperation mechanism with public personnel service agencies such as talent market and talent exchange center, and recruit enterprise-oriented talents.

In the aspect of technology, qualified enterprises can establish R&D center, technology center and other innovation base through the cooperation with universities and research institutes. At the same time, transfer mechanism of innovation achievements with universities and research institutes should be speeded up to boost agglomeration of more advanced and applicable technology for SMEs.

(3) Further strengthening government's guidance and support to collaborative innovation for SMEs.

First of all, government should pay more attention to the guidance of collaborative innovation for SMEs in policy making and policy arrangements. Secondly, government should make more efforts to encourage SMEs carrying out collaborative innovation with universities and research institutes and exchange and cooperation of projects.

In addition, it is necessary for the government to provide necessary financial special funds to support collaborative innovation for SMEs, such as establishing special funds for collaborative innovation plan, appropriately arranging funds of transformation of achievement of science and technology, taking part in setting up of scientific research platform and so on.

(4) Forming and improving transfer and diffusion mechanism of innovation technology and innovation achievements to increase efficiency of collaborative innovation for SMEs.

Enterprises-universities-researches cooperation platform between SMEs, university and research institutions are to be established to promote timely and effective transfer and transformation of scientific research achievements to SMEs. What's more, the mechanism of transformation of market oriented innovation

achievements are to be established to promote close integration of science and technology output and the development demand of SMEs, to further strengthen spread of and application of innovative achievement.

5. Epilogues

This paper attempts to make theoretical analysis and empirical research makes analysis on SMEs' collaborative innovation driving factors and the mechanism internally and externally, which comes to some meaningful conclusions, but there are still some limitations: firstly, the effect that technology ability has on SMEs' collaborative innovation has not been verified because enterprise technical ability factor has not been obtained in the empirical analysis; secondly, the research hypotheses on the pressure of market competition factors has been only partially supported. Therefore, more next works should be considered: on the one hand, questionnaires are to be revised to further improve the design of technological capabilities of enterprises and market competition pressure measurement items of scale; on the other hand, the scope of sample survey and the survey area are to be expanded to improve the representativeness of the sample.

Acknowledgments

The research work was sponsored by Soft Scientific Research Project of Ningbo under 2014A10023, Philosophy and Social Sciences Planning Project of Zhejiang Province under Grant under 16NDJC102YB.

References

- Chen Jin, Yang Yinjuan, 2012, Driven Mechanism of Collaborative Innovation, *Technology Economics*, 31(8), 6-11, DOI: 10.3969/j.issn.1002-980X.2012.08.002.
- Di Junpeng, 2007. Effective Demand of Enterprises on Technical Innovation. *Productivity Research*, (2), 114-115.
- He Haiyan, Wang Zwen, Jiang Lidan, Cai Jing-jing, 2014, A Research on Influencing Factors of Collaborative Innovation of Enterprises Universities and Research Institutes in China: An Empirical Analysis Base on Ordered Logit Model. *East China Economic Management*, 28(9), 106-110, DOI: 10.3969/j.issn.1007-5097.2014.09.019.
- Hu Wei, Zhou Yangmin, Cao Donghua, 2012, Collaborative Innovation between Subject Clusters and Industrial Clusters, Henan Science and Technology Press, Zhengzhou, China.
- Qi Shaoping, Zhang Jing, 2013, Research on Dynamic Mechanism of Regional Collaborative Innovation. *Seeker*, (2), 230-232, DOI: 10.16059/j.cnki.cn43-1008/c.2013.02.082.
- Qin Dezhi, Lei Sen, Xianyu Deqing, 2008, The Static Comprehensive Evaluation on Capabilities Osculating Value of Enterprise Technology, *Statistics and Decision*, (19), 78-80, DOI: 10.13546/j.cnki.tjyc.2008.19.029.
- Tong Jinjie, Lin Liang, Zuo Yi, 2015, Empirical Analysis of Influencing Factors of Coordinated Innovation in Small & Medium-Sized Enterprises in Jiangxi Province: Take Industrial Technology Innovation Alliance as an Example. *Science Mosaic*, (2), 172-177, DOI: 10.13838/j.cnki.kjgc.2015.02.037.
- Wei Jiang, 1998, Study on Technological Capabilities based on Knowledge Concept, *Studies in Dialectics of Nature*, 14(11), 54-60.
- Wu Cangnan, 2008, Analysis and Inspiration on Relationship of Independent Innovation and Imitation Innovation, *Science & Technology and Economy*, 21(4), 62-64, DOI: 10.3969/j.issn.1003-7691.2008.04.017.
- Xie Xuemei, 2015. An Empirical Study on Multidimensional Relationships Between Factors of Synergic Innovation of Firms and Their Synergic Degree. *Science Research Management*, 36(2), 69-78.
- Zhang Hongshi, Fu Yuxiu, 2005, Theory Analysis and Demonstration Study on the Environmental Factors of Radical Innovation, *Studies in Science of Science*, 23(z1), 255-263, DOI: 10.16192/j.cnki.1003-2053.2005.s1.054.